Periodic Trends

Part I: Atomic Radius

Analogy

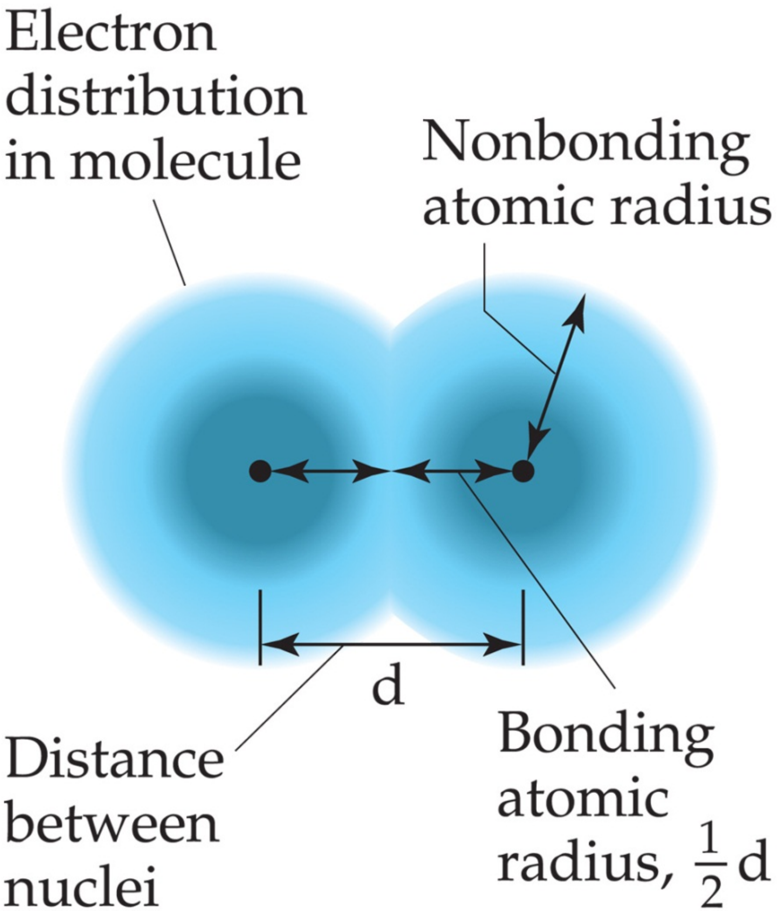
- How could we measure the diameter of cotton candy?

Atomic Radius

- Can’t be measured directly!

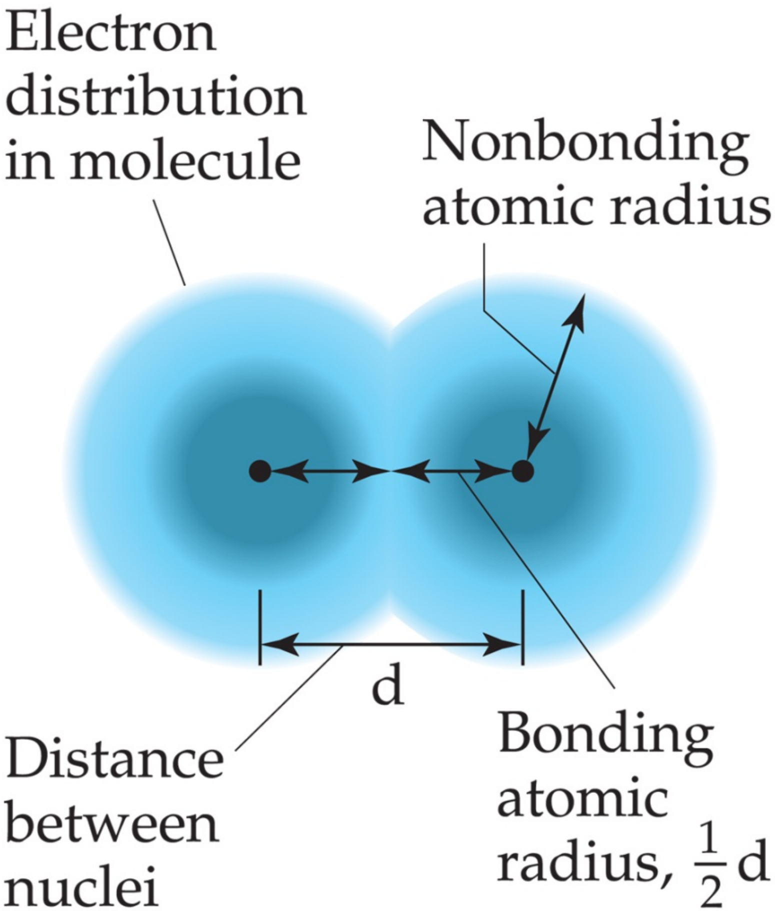
Atomic Radius

- Can't be measured directly!
- Use x-ray diffraction to measure internuclear distance



Atomic Radius

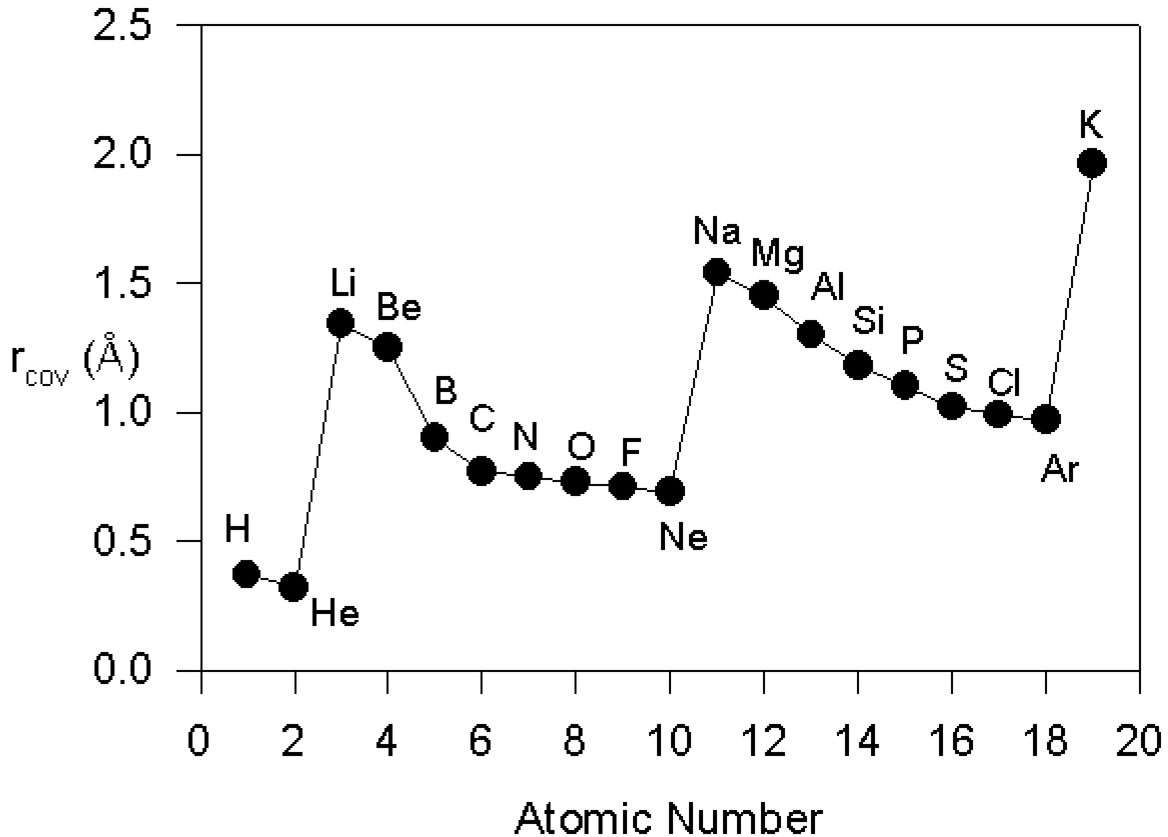
- Can’t be measured directly!
- Use x-ray diffraction to measure internuclear distance
- Radius = ½ d



Exploring the periodic taable

- Interactive

Covalent Radius versus Atomic Number

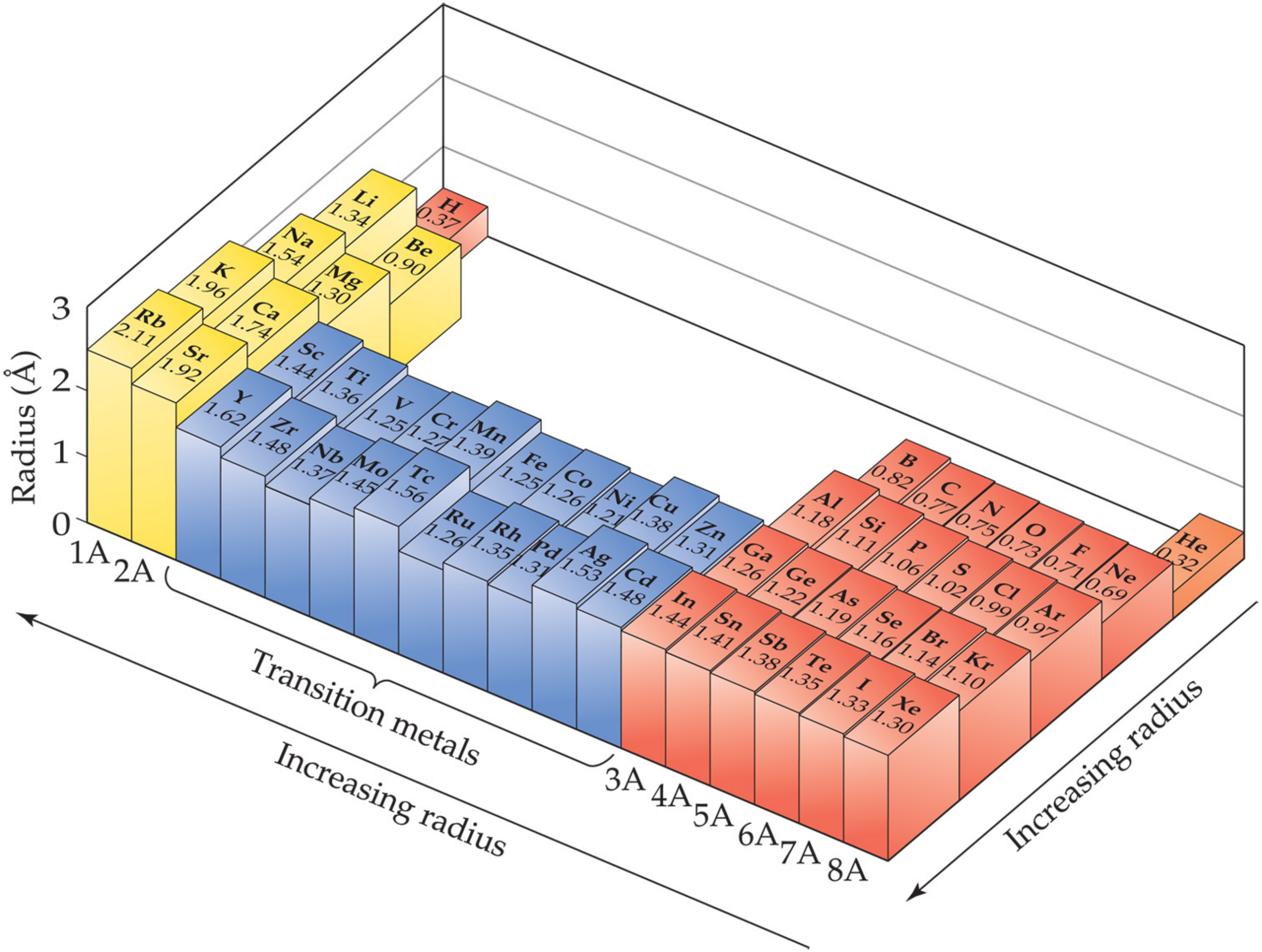


Trends in atomic radius

- Look at your graphs…
- Period trend
  - As you go from L → R in a period, atomic radius DECREASES

Trends in atomic radius

- Look at your graphs…
- Group trend
  - As you go down a column, atomic radius INCREASES


Radius (Å)
0
1
2
3
Li 1.34
H 0.37
Na 1.54
Be 0.90
K 1.96
Mg 1.30
Ca 1.74
Rb 2.11
Sr 1.92
Sc 1.44
Ti 1.36
Y 1.62
Zr 1.48
V 1.25
Cr 1.27
Mn 1.39
Nb 1.37
Mo 1.45
Tc 1.56
Fe 1.25
Co 1.26
Ni 1.21
Cu 1.38
Zn 1.31
Ru 1.26
Rh 1.35
Pd 1.31
Ag 1.53
Cd 1.48
B 0.82
C 0.77
N 0.75
O 0.73
F 0.71
Ne 0.69
He 0.32
Al 1.18
Si 1.11
P 1.06
S 1.02
Cl 0.99
Ar 0.97
Ga 1.26
Ge 1.22
As 1.19
Se 1.16
Br 1.14
Kr 1.10
In 1.44
Sn 1.41
Sb 1.38
Te 1.35
I 1.33
Xe 1.30
1A
2A
Transition metals
3A
4A
5A
6A
7A
8A
Increasing radius
Increasing radius

Practice Problems

- For the elements: Li, O, C, F
  - Largest?
  - Smallest?

- For the elements: Br, At, F, I, Cl
  - Largest?
  - Smallest?

Practice Problems

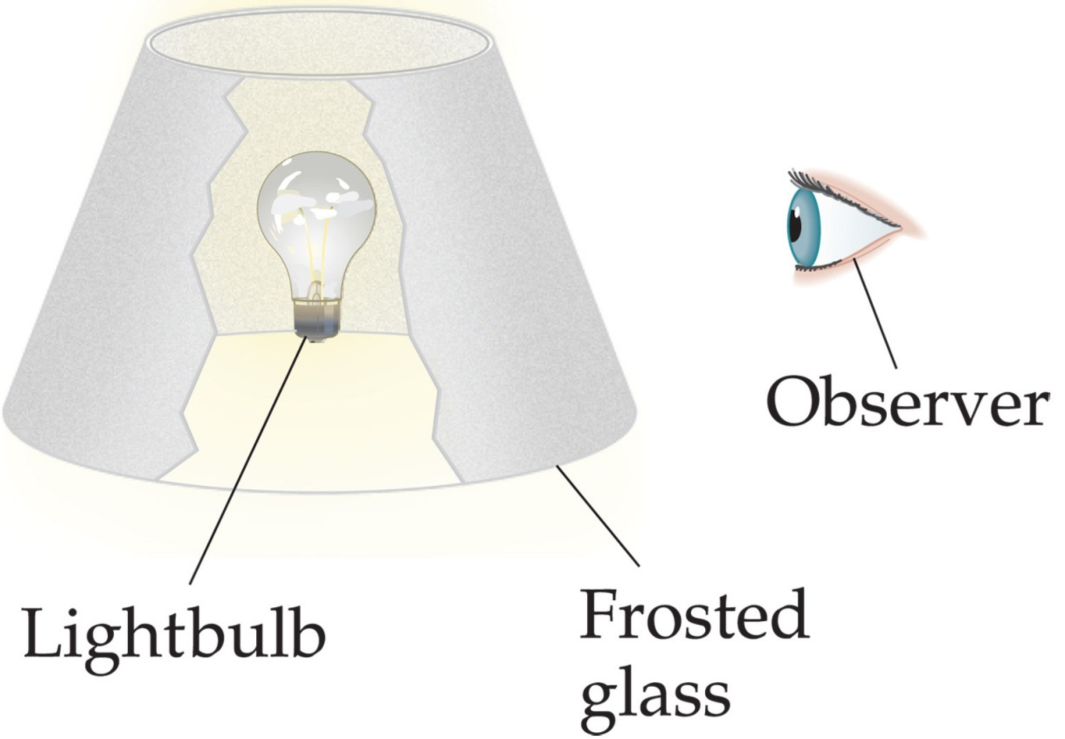
- Consider the elements: B, Al, N
  - Smallest?
  - Largest?

- Consider the elements: Be, Na, Rb, Mg
  - Smallest?
  - Largest?

Why?

- Shielding
- Effective nuclear charge

Shielding



Shielding

- The inner electrons “block” some of the nuclear charge
  - The valence electrons do not “feel” all of the nuclear charge
  - Shielding is CONSTANT across a period

Shielding

- The inner electrons “block” some of the nuclear charge
  - The valence electrons do not “feel” all of the nuclear charge

  - Shielding INCREASES down a column
    - More core (inner) electrons

Effective Nuclear Charge, Z_{eff}

- The amount of nuclear charge the electrons experience
- Visual approach
- Short video

Effective Nuclear Charge, Z_{eff}

- The amount of nuclear charge the electrons experience
  - The number of protons increases as you go left to right in a period

Effective Nuclear Charge, Z_{eff}

- The amount of nuclear charge the electrons experience
  - The number of protons increases as you go left to right in a period
  - So, as you go from left to right, the outermost electrons experience more nuclear charge

Explaining the atomic radius trend

- Atom radius decreases from left to right

Explaining the atomic radius trend

- Atom radius decreases from left to right
  - Because the outermost electrons are held more tightly

Explaining the atomic radius trend

- Atomic radius decreases from left to right…
  - because the outermost electrons are held more tightly
    - Z_{eff} increases left to right but shielding is constant

Explaining the atomic radius trend

- Atomic radius increases down a column

Explaining the atomic radius trend

- Atomic radius increases down a column
  - More core electrons → more $e^-:e^-$ repulsions

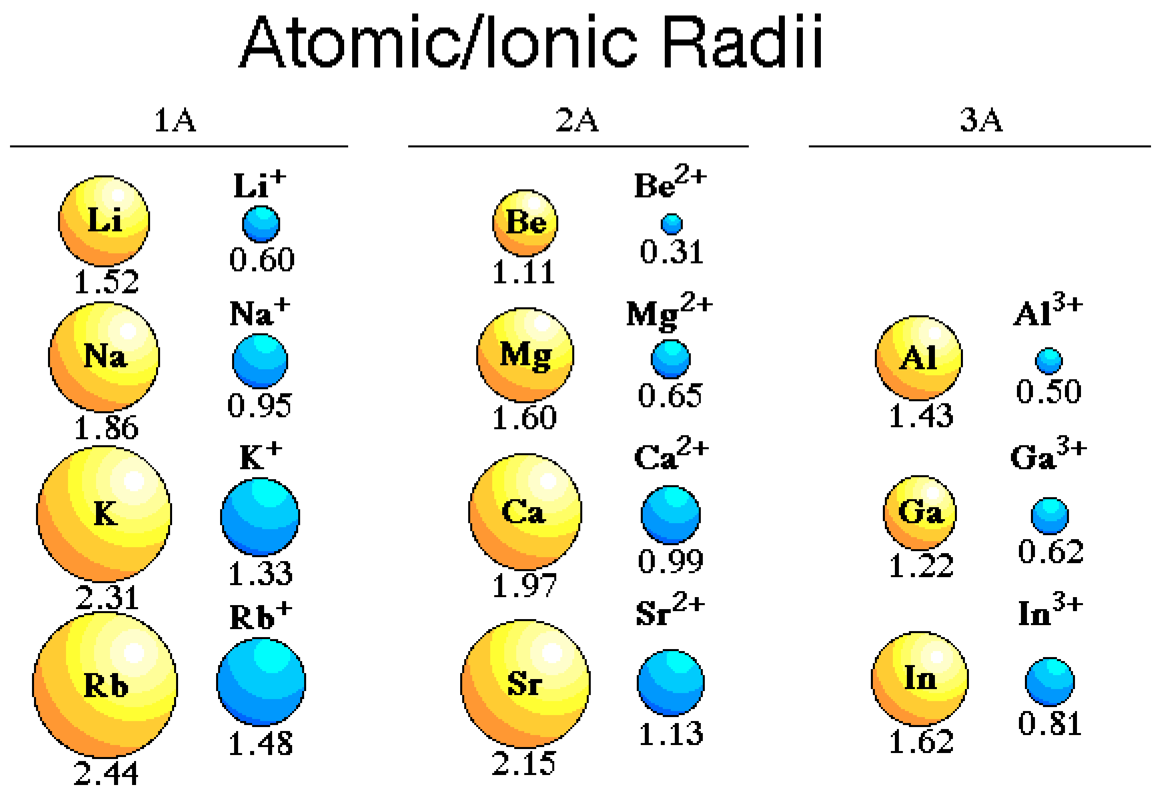
Explaining the atomic radius trend

- Atomic radius increases down a column
  - More core electrons → more shielding
  - Valence electrons are placed in higher energy levels farther from the nucleus
    - Outermost electrons are not held tightly

Ions

- Cations
- Anions

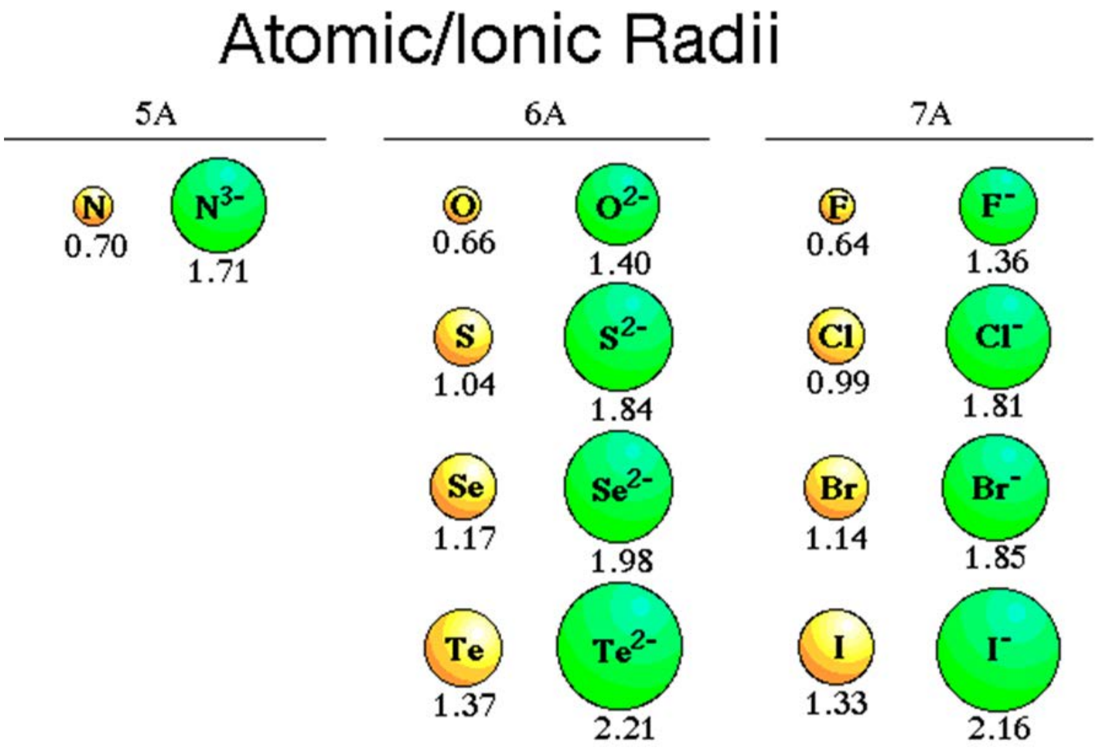
Cation vs. parent atom



Cation vs. parent atom

- Cations typically have a SMALLER radius than the parent atom
  - Why?
    - Fewer electrons
    - Fewer electron-electron repulsions
    - More protons than electrons

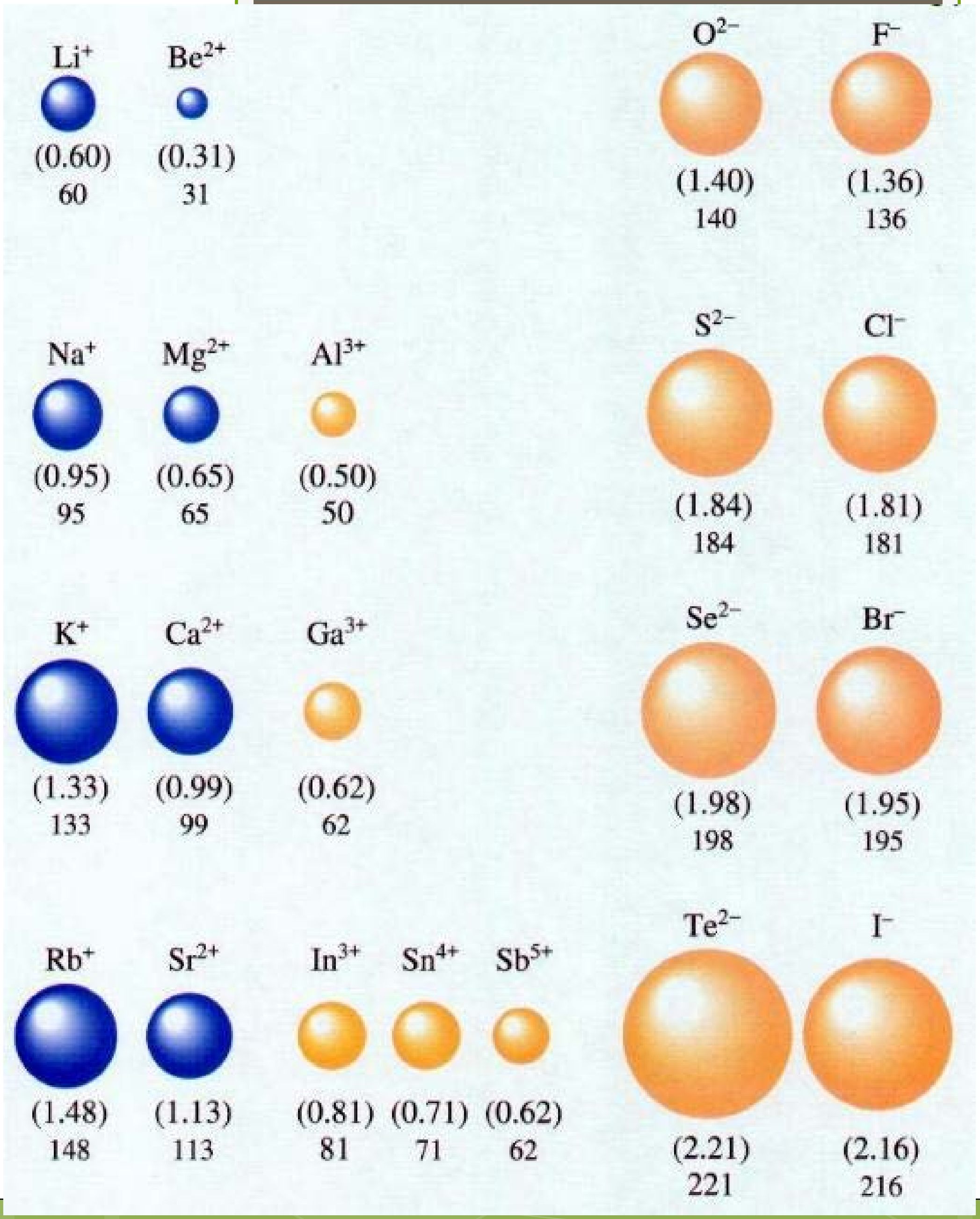
Anions


Atomic/Ionic Radii
5A
6A
7A
N
0.70
N3-
1.71
O
0.66
O2-
1.40
F
0.64
F-
1.36
S
1.04
S2-
1.84
Cl
0.99
Cl-
1.81
Se
1.17
Se2-
1.98
Br
1.14
Br-
1.85
Te
1.37
Te2-
2.21
I
1.33
I-
2.16

Anions vs. parent atom

- Anions typically have LARGER radii than the parent atoms
- Why?
  - More electron-electron repulsions
  - Fewer protons than electrons

Ionic Radius Trends



Summary of trends

- Group trend
- Period trend

Which of the following would have the larger radius?

- Ca or Ca^{2+}
- K^{+} or Sc^{3+}
- P or P^{3-}
- Cl^{-} or I^{-}
- Ca^{2+} or Cl^{-}
- P^{3-} or S^{2-}

Make a concept map

- Include the following terms (you may include other terms if you wish)
- Atomic radius
- Ionic radius
- Group
- Period

Basic concept map rubric

Key: $\surd_m$ = standard met $\surd_p$ = standard partially met $\surd_n$ = standard not met			
$\surd_{\mathbf{m}}$	$\surd_p$	$\surd_n$	All concepts are connected to another concept.
$\surd_{\mathbf{m}}$	$\surd_p$	$\surd_n$	All links are labeled.
$\surd_{\mathbf{m}}$	$\surd_p$	$\surd_n$	All links make grammatical sense (i.e., read as complete sentences).
$\surd_{\mathbf{m}}$	$\surd_p$	$\surd_n$	All links make scientific sense.